11.0 ECOLOGICAL RISK CONCLUSIONS

Risk estimates in this BERA were calculated following CERCLA guidance (EPA 1997, 1998) and EPA's Problem Formulation (Attachment 2). The conclusions of the BERA, along with those of the BHHRA (Appendix F of the draft final RI (Integral et al. 2011)), are intended to provide information to risk managers on potentially unacceptable risks predicted under current conditions of the Study Area, as well as information on possible future approaches for protecting human health and the environment.

The BERA's risk conclusions are provided at the end of the risk assessment for each receptor group:

- In Section 6.7 for benthic community assessment endpoints
- In Section 7.6 for fish assessment endpoints
- In Section 8.3 for avian and mammalian assessment endpoints
- In Section 9.3for the amphibian assessment endpoint
- In Section 10.3 for the aquatic plant assessment endpoint

Consistent with ERAGs (EPA 1997) the foregoing risk conclusions identified the receptor-COPC pairs that, given the magnitude and extent of risk, are reasonably likely to result in adverse effects on the assessment endpoints selected to represent the valued ecological attributes of the Study Area. Section 11 does not recapitulate the analyses that went into drawing the risk conclusions. For that level of detail the reader is referred back to the aforementioned risk conclusion sections. The remainder of Section 11 is organized as follows:

- Section 11.1 presents a summary by receptor group and LOE of the ~~89~~~~[1]~~ 102 ecological COPCs identified as posing potentially unacceptable risk in this BERA based on HQ ≥ 1 for at least one receptor-LOE combination.
- Section 11.2 identifies COPCs identified as posing potentially unacceptable risks for ecological receptors in the Study Area that occur at concentrations similar to the sediment and surface water background levels defined in Section 7.0 of the draft final RI (Integral et al. 2011) or to tissue concentrations in four fish receptor species (i.e., juvenile Chinook salmon, brown bullhead, smallmouth bass, and lamprey ammocoetes) collected from the upriver reach of the Willamette River (RM 15.3 to RM 28.4).
- Section 11.3 combines the risk conclusions across all ecological receptor groups to provide a general overview of ecological risks and to identify the

~~[1] Ninety-one contaminants have HQs ≥ 1. Because petroleum compounds are not CERCLA contaminants, gasoline-range hydrocarbons and diesel-range hydrocarbons have been excluded from the final count even though they may be contributing to potentially unacceptable risk.~~

Comment [A1]: Footnote 1 was pointed out to be in error by EPA in our draft final BERA comments (Comment 132). TPH is a CERCLA contaminant. The TPH in sediment TRVs were given to LWG on April 11, 2008, including the methodology of their derivation and a table with the numeric values corresponding to Oregon's aromatic and aliphatic TPH fraction definitions. Section 5.2 of the BERA discusses these TPH TRVs, which should also have been used in the BERA in the absence of any modified TPH TRVs.

receptor-COPC pairs that, given the magnitude and extent of risk, are reasonably likely to result in adverse effects on the assessment endpoints.

Risk management recommendations from the LWG risk assessors to EPA risk managers, based on the results of the BERA, are presented in Section 12.

11.1 SUMMARY OF POTENTIALLY UNACCEPTABLE RISKS

Consistent with EPA Superfund ERA guidance (EPA 1997, 1998), potentially unacceptable risks were identified through an iterative process of analyzing the exposure and effects data for the various chemicals and ecological receptors, with increasing realism at each step in the process. For most receptors, several LOEs were evaluated (Section 3.3). For each LOE, risk characterization began with the SLERA (Section 5) and progressed iteratively through the final step in the risk characterization. Throughout the process, chemical-receptor pairs that showed the potential for adverse effects were further analyzed and those that did not were screened out. The final step in the process reflects the most realistic risk estimates. Potentially unacceptable risks were identified for each receptor-LOE-COPC combination based on the final step in the risk characterization.

Exposure data in the final step of the risk analysis were evaluated at the scale over which the receptors are likely to be exposed and, where pertinent, the variety of potentially contaminated prey the receptor may consume. For the least mobile receptors (e.g., benthic macroinvertebrates, sculpin, aquatic plants), exposure areas are no larger than the immediate area where samples were collected; for the most mobile receptors (e.g., white sturgeon, largescale sucker), the exposure areas encompass the entire Study Area. For moderately mobile receptors (e.g., smallmouth bass, mink) the Study Area is divided into several exposure areas each 1 to 3 miles long.

For all LOEs except sediment, numerical risk estimates were calculated as HQs (Equation 6-1). HQs were calculated separately for each receptor-LOE-COPC combination for each exposure area. Receptor-LOE-COPC combinations resulting in $HQ \geq 1$ in the final step of the risk characterization in any exposure area were identified as posing potentially unacceptable risk. For the sediment LOE, a location was identified as posing potentially unacceptable risk to benthic invertebrates if the sediment was toxic or predicted to be toxic based on a sediment COPC concentration that exceeded a site-specific SQV.

Those chemicals for which exposure or effects data were insufficient to evaluate the risk were also identified as posing potentially unacceptable risk, although risk is unknown. Potential risks from chemicals without TRVs cannot be quantified, and are an uncertainty in the BERA that may underestimate risks. Risk to benthic organisms, including clams and crayfish, could not be evaluated for 78 sediment COIs because either no relationship between sediment contaminants and toxicity was apparent in the site-specific dataset or too few data points were available to discern a relationship (Table 6-6 summarizes the selection of chemicals for evaluation of site-specifc toxicity). Other contaminants that could not be evaluated for their contribution to benthic community risks include 27 tissue

COIs (Table 6-28), 19 surface water COIs (Table 6-35), and 16 TZW COIs (Table 6-42). Risk to fish from a number of COIs could not be evaluated: 17 tissue-residue COIs (Table 7-13), 11 dietary COIs (Table 7-16), 5 surface water COIs (Table 7-40), and 9 TZW COIs (Table 7-43). Risk to birds and mammals from dietary exposure to 19 COIs could not be evaluated (Table 8-30). Risk to amphibians and aquatic plants from 27 COIs (including 19 surface water COIs and 16 TZW COIs) could not be evaluated (Tables 5-11, 5-12, and 6-35 for surface water; Table 6-42 for TZW). As per agreement with EPA (LWG 2010), these COIs are identified as chemicals for which no TRV is available as well as chemicals whose maximum DL exceeded a TRV but whose detected values did not.

Risk assessments are, by design, conservative in the face of uncertainty. However, not all uncertainties create a conservative bias. Some examples of uncertainties that could lead to underestimation of risk include unavailability of exposure or effects data; existing TRVs that might underestimate risk for untested sensitive species; synergistic interactions among the multiple chemicals; and metabolic processes that increase the toxicity of accumulated chemicals.

There is no single 'best' method for summarizing potentially unacceptable ecological risks in a site as large and complex as Portland Harbor, or in a site with as many contaminants posing potentially unacceptable risks. Each reader of the BERA is likely to have need for or interest in different aspects of the risk assessment. Some readers will be interested in chemicals posing potentially unacceptable risks in each medium or sample type; others may be interested in risks to specific assessment or measurement endpoints; while others may be interested in risks within a specific river mile or other geographic locator.

In an effort to make this section as useful to as many readers as possible, the chemicals posing potentially unacceptable risks are sorted and presented in several different ways: by line of evidence, receptor group, assessment endpoint, and by media within each river mile of the Study Area. BERA Attachment 19 provides additional summary details on magnitude and locations of risk not fully presented in this section.

Table 11-1 tallies the COPCs (individual chemicals, sums, or totals) identified as posing potentially unacceptable risk for each assessment endpoint and Table 11-2 provides a more general summary for each ecological receptor group. In total, ~~89~~ 102 CERCLA contaminants were identified as posing potentially unacceptable risk in this BERA based on HQ ≥ 1 for at least one receptor-LOE combination. The number of contaminants identified as posing potentially unacceptable risks drops to 74 if all of the individual compound or mixture TRV's for PCB's, DDx (i.e. the various DDD, DDE and DDT compounds) and PAH's are condensed into total PCB, total DDx and total PAH groupings. The maximum HQs and numbers of samples resulting in HQ ≥ 1 for each

Comment [A2]: Specific table numbers will need to be added here. The individual tables, particularly the table by river mile and medium within each river mile need to be generated. The draft table by assessment endpoint, measurement endpoiont and line of evidence has already been shared with LWG, and will be presented as a summary table for Sections 6 through 10, for each major ecological receptor category.

receptor-LOE-COPC combination posing potentially unacceptable risk are presented in Attachment 19:[2]

- Benthic invertebrates – Eighty-three COPCs were identified via one or more of the sediment, tissue-residue, surface water, and TZW LOEs.3
- Fish – Fifty nine COPCs were identified using the tissue-residue, dietary-dose, surface water, and TZW LOEs.4
- Wildlife – Twelve COPCs were identified for birds using the dietary-dose and tissue-residue (egg) LOEs, and six COPCs were identified for mammals using the dietary-dose LOE.
- Amphibians – Thirty-three COPCs were identified using the surface water and TZW LOEs.5
- **Aquatic plants** – Thirty-three COPCs were identified using the surface water and TZW LOEs.[6]

The spatial extent, magnitude and potential ecological significance of TRV exceedances and the concordance among LOEs were considered to determine risk conclusions for contaminants posing potentially unacceptable risk. The analyses used to draw these conclusions are presented for each receptor group in Sections 6.7, 7.6, 8.3, 9.3, and 10.3. The main conclusions of the BERA by receptor group are briefly summarized below in Section 11.3.

Comment [A3]: Will need to retabluate the PUR chemical counts for all of the below bullets.

[2] Counts of COPCs with HQs ≥ 1 are based on HQs derived using both EPA national ambient water quality criteria (AWQC) and the alternative surface water TRVs for total PCBs, 4,4′-DDT, and total DDx derived in this BERA. Both sets of TRVs identify 4,4’-DDT and total DDx as having HQs ≥ 1 in both surface water and TZW. Total PCBs have samples with HQ ≥ 1 in surface water using the AWQC-based TRV, but not the BERA alternative TRV. Neither PCB TRV identifies total PCB as posing potentially unacceptable risk in TZW.~~, as opposed to the AWQC-based TRVs.~~

[3] Eighty-five benthic invertebrate COPCs have HQs ≥ 1. Petroleum compounds are not CERCLA contaminants, and have been excluded from the final COPC count for sediment and TZW LOEs even though this chemical group may be contributing to potentially unacceptable risk.

[4] Sixty fish COPCs have HQs ≥ 1. Petroleum compounds are not CERCLA contaminants and have been excluded from the COPC count for the TZW LOE even though this chemical group may be contributing to potentially unacceptable risk.

[5] Thirty-four amphibian COPCs have HQs ≥ 1. Petroleum compounds are not CERCLA contaminants and have been excluded from the COPC count for the TZW LOE even though this chemical group may be contributing to potentially unacceptable risk.

[6] Thirty-four aquatic plant COPCs have HQs ≥ 1. Petroleum compounds are not CERCLA contaminants and have been excluded from the COPC count for the TZW LOE even though this chemical group may be contributing to potentially unacceptable risk.

Table 11-1. COPCs with HQ ≥ 1 Organized by Assessment Endpoint and Line of Evidence for the Portland Harbor BERA

Line of Evidence (LOE)	COPCs with HQ ≥ 1
Assessment Endpoint:[a] Benthic Invertebrate Survival, Growth, and Reproduction	
Macroinvertebrates (e.g., amphipods, isopods, bivalves, gastropods, oligochaetes, insects, decapods)	
Survival and biomass of *Chironomus dilutus* and *Hyalella azteca* exposed to site sediments compared with reference area sediments	Responses based on chemical mixtures; no individual COPCs identified
Concentrations in site sediment compared with effect levels derived from FPM and LRM models (i.e., SQVs) predicting reduced survival or biomass based on Portland Harbor surface sediment concentrations and toxicity reported for both *Hyalella* and *Chironomus* endpoints	6 metals, TBT, 19 individual PAHs or group sums, dibutyl phthalate, 3 SVOCs, 2 phenolic compounds, PCBs, 15 individual pesticides or group sums
Concentrations in site sediment compared with national consensus-based SQGs (PECs and related quotients), and effects-based SQGs (PELs, and related quotients)	8 metals, 14 individual PAHs or group sums, 2 PCBs, 9 individual pesticides or group sums
Concentrations in surface water compared with state WQS, national AWQC, or effects-based values derived from the literature that are protective of benthic macroinvertebrate survival, growth, and reproduction	Zinc, monobutyltin, benzo(a)anthracene, benzo(a)pyrene, naphthalene, BEHP, total DDx,[b] ethylbenzene, trichlorethene
Concentrations in shallow TZW compared with state WQS, national AWQC, or effects-based values derived from the literature that are protective of benthic macroinvertebrate survival, growth, and reproduction	14 metals, 16 individual PAHs, 3 SVOCs, the pesticides 4,4′-DDT[b] and total DDx,[b] 16 VOCs, gasoline–range hydrocarbons, cyanide and perchlorate
Empirical (field-collected) whole-body concentrations of epibenthic organisms compared with tissue TRVs	None
Steady-state estimates of laboratory-exposed whole-body concentrations in *Lumbriculus* compared with tissue TRVs	Arsenic, copper, zinc, TBT, PCBs, total DDx
Predicted (BSAF) whole-body concentrations of *Lumbriculus* compared with tissue TRVs	TBT, PCBs, total DDX
Bivalves (clams, mussels)	
Empirical (field-collected) whole-body concentrations in *Corbicula fluminea* and freshwater mussels compared with tissue TRVs	Copper, zinc, TBT, PCBs
Steady-state estimates of laboratory-exposed whole-body concentrations in *Corbicula fluminea* compared with tissue TRVs	TBT, BEHP, total DDx

Table 11-1. COPCs with HQ ≥ 1 Organized by Assessment Endpoint and Line of Evidence for the Portland Harbor BERA

Line of Evidence (LOE)	COPCs with HQ ≥ 1
Predicted (BSAF) whole-body concentrations in *Corbicula fluminea* compared with tissue TRVs	Total PCBs, total DDx
Corbicula fluminea survival compared with control data from bioaccumulation tests	Responses based on chemical mixtures; no individual COPCs identified
Survival and biomass of *Chironomus dilutus* and *Hyalella azteca* exposed to site sediments, compared with reference sediments	Responses based on chemical mixtures; no individual COPCs identified
Concentrations in surface water compared with state WQS, national AWQC, or effects-based values derived from the literature that are protective of benthic macroinvertebrate survival, growth, and reproduction	Zinc, monobutyltin, benzo(a)anthracene, benzo(a)pyrene, naphthalene, BEHP, total DDx,[b] ethylbenzene, trichlorethene
Concentrations in shallow TZW compared with state WQS, national AWQC, or effects-based values derived from the literature that are protective of benthic macroinvertebrate survival, growth, and reproduction	14 metals, 16 individual PAHs, 3 SVOCs, the pesticides 4,4′-DDT[b] and total DDx,[b] 16 VOCs, gasoline-range hydrocarbons,[c] cyanide and perchlorate
Concentrations in site sediment compared with national consensus-based SQGs (PECs and related quotients) and effects-based SQGs (PELs and related quotients)	8 metals, 14 individual PAHs or group sums, 2 PCBs, 9 individual pesticides or group sums
Decapods (crayfish)[d]	
Empirical whole-body concentrations in crayfish compared with tissue TRVs	Copper
Predicted (BSAF or FWM) whole-body concentrations in crayfish compared with tissue TRVs	Total PCBs, total DDx
Concentrations in site sediment compared with national consensus-based SQGs (PECs and related quotients) and effects-based SQGs (PELs and related quotients)	8 metals, 14 individual PAHs or group sums, 2 PCBs, 9 individual pesticides or group sums
Concentrations in surface water compared with state WQS, national AWQC, or effects-based values derived from the literature that are protective of benthic macroinvertebrate survival, growth, and reproduction	Zinc, monobutyltin, benzo(a)anthracene, benzo(a)pyrene, naphthalene, BEHP, total DDx,[b] ethylbenzene, trichlorethene
Concentrations in shallow TZW compared with state WQS, national AWQC, or effects-based values derived from the literature that are protective of benthic macroinvertebrate survival, growth, and reproduction	14 metals, 16 individual PAHs, 3 SVOCs, the pesticides 4,4′-DDT[b] and total DDx,[b] 16 VOCs, gasoline–range hydrocarbons,[c] cyanide and perchlorate

Table 11-1. COPCs with HQ ≥ 1 Organized by Assessment Endpoint and Line of Evidence for the Portland Harbor BERA

Line of Evidence (LOE)	COPCs with HQ ≥ 1
Assessment Endpoint:[a] Fish Survival, Growth, and Reproduction	
Omnivorous Fish (white sturgeon, largescale sucker[e])	
Empirical whole-body concentrations compared with tissue TRVs	Total PCBs
Dietary dose (including incidental sediment ingestion) compared with dietary TRVs	Copper
Concentrations in surface water compared with state WQS, national AWQC,[b] or effects-based values derived from the literature that are protective of fish survival, growth, and reproduction	Zinc, monobutyltin, benzo(a)anthracene, benzo(a)pyrene, naphthalene, BEHP, total DDx[b], 4,4'-DDT[b], trichloroethene, ethylbenzene, total PCB[b]~~No COPCs with HQs ≥ 1~~
Correlation of lesion prevalence with areas of contamination and/or comparison to lesion-based TRVs (if relevant to receptor species)[7]	Inconclusive for PAHs
Invertivorous Fish (juvenile Chinook salmon,[f] peamouth, sculpin)	
Empirical whole-body concentrations compared with tissue TRVs	Copper, lead, total PCBs, total DDx
Predicted (BSAF or FWM) whole-body concentration compared with tissue TRVs (sculpin only)	Total PCBs, total DDx
Dietary dose (including incidental sediment ingestion) compared with dietary TRVs	Cadmium, copper, TBT
Concentrations in surface water compared with state WQS, national AWQC or effects-based TRVs reported in the literature	Zinc, monobutyltin, benzo(a)anthracene, benzo(a)pyrene, naphthalene, BEHP, total DDx[b], trichlorethene
Concentrations in shallow TZW compared with state WQS, national AWQC or effects-based TRVs reported in the literature (sculpin only)	14 metals, 16 PAHs, 3 SVOCs, the pesticides 4,4′-DDT[b] and total DDx,[b] 16 VOCs, gasoline-range hydrocarbons,[c] cyanide and perchlorate
Piscivorous Fish (northern pikeminnow, smallmouth bass)	
Empirical whole-body concentrations compared with tissue TRVs	Antimony, lead, total PCBs

[7] The lesion prevalence line of evidence is not a primary LOE in the BERA, as it does not directly address any BERA assessment endpoint. Since effects on survival, growth or reproduction cannot be quantified from the lesion LOE, no quantitative risk management recommendations can be derived from the lesion LOE.

Comment [A4]: Footnote will need renumbered to match footnotes in rest of Table 11-1. Renumbering is an editorial change.

Table 11-1. COPCs with HQ ≥ 1 Organized by Assessment Endpoint and Line of Evidence for the Portland Harbor BERA

Line of Evidence (LOE)	COPCs with HQ ≥ 1
Predicted (BSAF or FWM) whole-body concentrations compared with tissue TRVs (smallmouth bass only)	This LOE was not evaluated because empirical tissue data were available from all exposure areas.
Concentrations in surface water compared with reported state WQS, national AWQC,[b] or effects-based TRVs reported in the literature	Zinc, monobutyltin, benzo(a)anthracene, benzo(a)pyrene, naphthalene, BEHP
Dietary dose (including incidental sediment ingestion) compared with dietary TRVs	Copper
Detritivorous Fish (Pacific lamprey ammocoete[f])	
Empirical whole-body concentration compared with tissue TRV	Copper
Concentrations in surface water compared with state WQS, national AWQC, or literature-based values that are protective of early life stages.	Zinc, monobutyltin, benzo(a)anthracene, benzo(a)pyrene, naphthalene, BEHP, total DDx[b], 4,4'-DDT[b], trichloroethene, ethylbenzene, total PCB[b] ~~No COPCs with HQs ≥ 1[b]~~
Concentration in shallow TZW compared with state WQS, national AWQC, or effects-based values reported in the literature that are protective of early life stages[g]	14 metals, 16 PAHs, 3 SVOCs, the pesticides 4,4′-DDT[b] and total DDx,[b] 16 VOCs, gasoline range hydrocarbons,[c] cyanide and perchlorate
Assessment Endpoint:[a] Bird Survival, Growth, and Reproduction	
Invertivorous Birds (spotted sandpiper)	
Dietary dose (including incidental sediment ingestion) compared with dietary TRV	Copper, benzo(a)pyrene, dibutyl phthalate, total PCBs, PCB TEQ, total dioxin/furan TEQ, total TEQ, sum DDE, total DDx, aldrin
Omnivorous Birds (hooded merganser)	
Dietary dose (including incidental sediment ingestion) compared with dietary TRV	Total PCBs
Piscivorous Birds (osprey, bald eagle)	
Dietary-based approach incorporating food chain transfer of contaminants from appropriate fish species (assuming all exposure comes from prey fish) and incidental sediment ingestion	Lead, mercury, total PCBs
Measured concentrations in osprey eggs compared with egg- or embryo-based TRVs for DDT and metabolites, PCBs, and dioxin-like compounds	Total PCBs, PCB TEQ, total dioxin/furan TEQ, total TEQ, sum DDE[h]

Table 11-1. COPCs with HQ ≥ 1 Organized by Assessment Endpoint and Line of Evidence for the Portland Harbor BERA

Line of Evidence (LOE)	COPCs with HQ ≥ 1
Assessment Endpoint:[a] Mammal Survival, Growth, and Reproduction	
Aquatic-Dependent Mammals (mink, river otter)	
Dietary dose compared with dietary TRVs	Aluminum, lead, total PCBs, PCB TEQ, total dioxin/furan TEQ, total TEQ
Assessment Endpoint:[a] Amphibian Survival, Growth, and Reproduction (frogs, salamanders)	
Concentrations in surface water compared with state WQS, national AWQC, or effects-based values reported in the literature that are protective of sensitive life stages	Zinc, benzo(a)anthracene, benzo(a)pyrene, naphthalene, BEHP, total DDx[b]
Concentrations in shallow TZW compared with state WQS, national AWQC, or effects-based values reported in the literature that are protective of sensitive life stages	11 metals, 8 PAHs, the SVOC 1,2-dichlorobenzene, the pesticides 4,4′-DDT[b] and total DDx,[b] 8 VOCs, gasoline-range hydrocarbons,[c] and the conventionals cyanide and perchlorate
Assessment Endpoint:[a] Aquatic Plant Survival, Growth, and Reproduction (phytoplankton, periphyton, macrophytes)	
Concentrations in surface water compared with state WQS, national AWQC, or effects-based values derived from the literature that are protective of sensitive life stages (e.g., germination, emergence, early life stage growth)	Zinc, benzo(a)anthracene, benzo(a)pyrene, naphthalene, BEHP, total DDx[b]
Concentrations in shallow TZW compared with state WQS, national AWQC, or effects-based values derived from the literature that are protective of sensitive life stages (e.g., germination, emergence, early life stage growth)	11 metals, 8 PAHs, the SVOC 1,2-dichlorobenzene, the pesticides 4,4′-DDT[b] and total DDx,[b] 8 VOCs, gasoline-range hydrocarbons,[c] and the conventionals cyanide and perchlorate

[a] The assessment endpoints for all receptors are based on protection and maintenance of their populations and the communities in which they live, except that the health of threatened or endangered species is to be protected at the level of the individual organism. Per the SOW, EPA's Problem Formulation (Attachment 2), and as stated in the Programmatic Work Plan (Integral et al. 2004b), the assessment endpoints were expressed as the survival, growth, and reproduction of each receptor group.

[b] Risk estimates for total PCBs, 4,4′-DDT, and total DDx for the surface water and TZW LOEs are based HQs derived using both EPA national ambient water quality criteria (AWQC) and the alternative surface water TRVs for total PCBs, 4,4′-DDT, and total DDx derived in this BERA. Both sets of TRVs identify ~~4,4′-DDT and~~ total DDx as having HQs ≥ 1 in both surface water and TZW. Total PCBs and 4,4'-DDT have samples with HQ ≥ 1 in surface water using the AWQC-based TRV, but not the BERA alternative TRV. Neither PCB TRV identifies total PCB as posing potentially unacceptable risk in TZW. ~~on the alternative total PCBs and 4,4′-DDT TRVs for protection of directly exposed aquatic organisms, rather than the selected AWQC-based TRVs. Additional exceedances occur using the AWQC-based TRVs and HQs, as presented in the surface water and TZW risk characterization sections for each receptor group.~~ The alternative TRVs are considered more appropriate for evaluating direct exposure of aquatic organisms because the national AWQC are based on protection of dietary risks to mammals and birds.

[c] ~~The HQ for gasoline-range hydrocarbons is ≥ 1; however the COPC was not included in the counts of COPCs with HQs ≥ 1 because counts are based only on CERCLA contaminants.~~

Comment [A5]: Footnote C need deleted, and the remaining footnotes relettered. EPA considers the TPH fractions to be CERCLA contaminants.

[d] Although these LOEs are components of the benthic invertebrate community, the bivalve population and decapod population assessment endpoints are presented separately in this table. Evaluation of sediment toxicity to *Chironomus* and *Hyalella* and comparison of surface water and shallow TZW concentrations to TRVs were each conducted and presented only once as part of the benthic invertebrate community assessment. Similarly, comparison of sediment concentrations to published SQGs also occurred and was presented only once as part of the benthic community assessment.

[e] Carp is not a receptor of concern for the BERA but whole-body carp tissue was analyzed for dioxin-like chemicals, including PCB congeners; for these chemicals, carp is a surrogate for other omnivorous fish species.

[f] Juvenile Chinook salmon and Pacific lamprey ammocoetes were evaluated at the organism level because they have special status are (juvenile Chinook is federally threatened and Pacific lamprey is an Oregon state sensitive species of special concern to Tribes); effect thresholds based on reproduction are used as a surrogate for growth in juvenile Chinook salmon and Pacific lamprey ammocoetes.

[g] The TZW exposure pathway for fish receptors is considered complete and significant for only sculpin and lamprey ammocoetes. The ecological CSM shows a complete TZW exposure pathway for sucker, carp, and sturgeon but categorizes the pathway as insignificant.

[h] Bald eagle only based on extrapolation from osprey eggs and comparison to a NOAEL-based TRV. For osprey, all HQ < 1.

AWQC – ambient water quality criteria
BEHP – bis(2-ethylhexyl) phthalate
BERA – baseline ecological risk assessment
BSAF – biota-sediment accumulation factor
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
COPC – contaminant of potential concern
CSM – conceptual site model
DDD – dichlorodiphenyldichloroethane
DDE – dichlorodiphenyldichloroethylene
DDT – dichlorodiphenyltrichloroethane
EPA – US Environmental Protection Agency
FWM – food web model
HQ – hazard quotient
LOE – line of evidence
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
PEC – probable effects concentration
PEL – probable effects level
SOW – scope of work
SQG – sediment quality guideline
SQV – sediment quality value
SVOC – semivolatile organic compound
TBT – tributyltin
TEQ – toxic equivalent
total DDx – sum of all six DDT isomers (2,4′-DDD, 4,4′-DDD, 2,4′-DDE, 4,4′-DDE, 2,4′-DDT, and 4,4′-DDT)
TRV – toxicity reference value
TZW – transition zone water
VOC – volatile organic compound
WQS – water quality standards

Table 11-2. Contaminants Posing Potentially Unacceptable Risk Organized by Receptor Group

COPC[a]	Benthic Invertebrates	Fish	Birds	Mammals	Amphibians	Aquatic Plants
Metals						
Aluminum				X		
Antimony		X				
Arsenic	X					
Barium	X	X			X	X
Beryllium	X	X				
Cadmium	X	X			X	X
Cobalt	X	X				
Copper	X	X	X		X	X
Iron	X	X			X	X
Lead	X	X	X	X	X	X
Magnesium	X	X			X	X
Manganese	X	X			X	X
Mercury		X	X			
Nickel	X	X			X	X
Potassium	X	X			X	X
Sodium	X	X			X	X
Vanadium	X	X				
Zinc	X	X			X	X
Butyltins						
Monobutyltin	X	X				
Tributyltin	X	X				
PAHs						
2-Methylnaphthalene	X	X			X	X
Acenapthene	X	X			X	X
Anthracene	X	X			X	X
Benzo(a)anthracene	X	X			X	X
Benzo(a)pyrene	X	X	X		X	X
Benzo(b)fluoranthene	X	X				
Benzo(g,h,i)perylene	X	X				
Benzo(k)fluoranthene	X	X				
Chrysene	X	X				
Dibenzo(a,h)anthracene	X	X				
Fluoranthene	X	X				

Table 11-2. Contaminants Posing Potentially Unacceptable Risk Organized by Receptor Group

COPC[a]	Benthic Invertebrates	Fish	Birds	Mammals	Amphibians	Aquatic Plants
Fluorene	X	X			X	X
Ideno(1,2,3-cd) pyrene	X	X				
Naphthalene	X	X			X	X
Phenanthrene	X	X			X	X
Pyrene	X	X				
Phthalates						
BEHP	X	X			X	X
Dibutyl phthalate			X			
SVOCS						
1,2-Dichlorobenzene	X	X			X	X
1,4-Dichlorobenzene	X	X				
Dibenzofuran	X	X				
PCBs						
Total PCBs	X	X	X[c]	X		
PCB TEQ			X[c]	X		
Dioxins/furan TEQ			X[c]	X		
Total TEQ			X[c]	X		
VOCs						
1,1-Dichloroethene	X	X				
1,2,4-Trimethylbenzene	X	X			X	X
1,3,5-Trimethylbenzene	X	X				
Benzene	X	X				
Carbon disulfide	X	X			X	X
Chlorobenzene	X	X			X	X
Chloroethane	X	X			X	X
Chloroform	X	X			X	X
cis-1,2-Dichloroethene	X	X				
Ethylbenzene	X	X			X	X
Isopropylbenzene	X	X			X	X
Toluene	X	X			X	X
Trichloroethene	X	X				
m,p-Xylene	X	X				
o-Xylene	X	X				
Total xylenes	X	X				

Table 11-2. Contaminants Posing Potentially Unacceptable Risk Organized by Receptor Group

COPC[a]	Benthic Invertebrates	Fish	Birds	Mammals	Amphibians	Aquatic Plants
Pesticides						
Aldrin			X			
4,4'-DDD	X					
sum DDE			X			
4,4’-DDT	X	X			X	X
Total DDx	X	X	X		X	X
Other Chemicals						
Cyanide	X	X			X	X
Perchlorate	X	X			X	X

[a] The COPCs listed in this table are CERCLA contaminants. Several additional contaminants may also contribute to potentially unacceptable risk. These contaminants include ~~TPH,~~ ammonia, and sulfides.

Comment [A6]: TPH is a CERCLA contaminant, and the appropriate fractions should be listed as such under surface water and sediment in Table 11-2.

BEHP – bis(2-ethylhexyl) phthalate
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
COPC – chemical of potential concern
DDD – dichlorodiphenyldichloroethane
DDE – dichlorodiphenyldichloroethylene
DDT – dichlorodiphenyltrichloroethane
HCH – hexachlorocyclohexane
HQ – hazard quotient
PAH –polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
TEQ – toxic equivalent
total DDx – sum of all six DDT isomers (2,4′-DDD, 4,4′-DDD, 2,4′-DDE, 4,4′-DDE, 2,4′-DDT, and 4,4′-DDT)

11.2 BACKGROUND AND UPRIVER CONCENTRATIONS

For all contaminants posing potentially unacceptable risk, Attachment 11 presents a comparison of background and Study Area 95th percentile UCLs in sediment and surface water. For aluminum, dibutyl phthalate, benzyl alcohol, and alpha-endosulfan, background sediment UCLs are the same as or higher than Study Area UCLs. The background surface water UCL concentration is higher than the Study Area UCL only for aluminum. Attachment 11 also includes a comparison of concentrations in fish tissue from the upriver reach and the Study Area for all fish tissue-residue and wildlife dietary contaminants posing potentially unacceptable risk. Although fish tissue data from the upriver reach are insufficient to allow calculation of UCLs, their concentrations are similar to those in the Study Area for aluminum, mercury, and copper, as presented in Section 7.1.5.

Background concentrations for sediment and surface water, and upriver concentrations for fish tissue provide context for Study Area risk predictions but were not used to discount risks or influence risk estimates. Where background concentrations exceed screening-level TRVs or upriver fish tissue concentrations exceed tissue TRVs, upriver or regional sources may be contributing to unacceptable risks in the Study Area.

11.3 ECOLOGICAL RISK CONCLUSIONS

The risk conclusions across all ecological receptor groups are combined and briefly summarized in this section to provide a general overview of ecological risks and to identify the receptor-COPC pairs that, given the magnitude and extent of risk, are reasonably likely to result in adverse effects on the assessment endpoints that were selected in the Problem Formulation to represent the valued ecological attributes of the Study Area. In other words, what is the ecological significance of the risks identified in Sections 6 through 10? To reiterate, the analyses used to draw these conclusions are presented in Sections 6.7, 7.6, 8.3, 9.3, and 10.3, and are not repeated here. For example, this section (11.3) contains statements with qualitative adjectives like “limited” or “moderate” when describing the spatial extent of exposure to a COPC at concentrations yielding HQs ≥ 1. Statements such as, “uncertainty in the tissue-residue TRV is more likely to over- than underpredict risk” are made without repeating the supporting evidence. EPA (1997) ecological risk assessment guidance calls for professional judgement on the part of risk assessors when evaluating the ecological significance of identified risks. In cases such as these, the reader interested in the details should refer back to the risk conclusions section for the relevant receptor group. The main conclusions of the BERA by receptor group are presented in Sections 11.3.1 through 11.3.5. Section 11.3 closes with a brief synopsis of potential future benthic community risks in erosional sections of the Study Area.

Comment [A7]: A discussion of ecological significance of risks needs to be appended as a new subsection to the end of Section 3.3 (assessment endpoint selection). The criteria for ecological significance EPA described in the draft executive summary can be expanded on in this new section. If the text added to Section 3.3 does a good job defining ecological significance, the text in Section 11.3 should largely be acceptable as written, with the exception of the last paragraph of Section 11.3.3.

11.3.1 Benthic Invertebrate Community

~~COPCs occur at concentrations that are projected to pose unacceptable benthic risks for about 7% of the Study Area~~Based on GIS estimates extrapolated from the empirical sediment toxicity data, Level 2 (moderate) and Level 3 (severe) toxicity combined are projected to extend over between 4 – 8% of the ~~area of~~ surface sediment area within the Study Area. Unlike other ecological receptors, for which risk was evaluated on a chemical-specific basis, risk to the benthic invertebrate community was evaluated in large part by considering exposure to the mixture of chemicals present in the Study Area sediments, using toxicity tests and multivariate predictive models based on the toxicity test results. Point-by-point assessment of potential effects on benthic organisms using data from toxicity testing, modeling, and benthic tissue-residue analyses indicates that metals, TBT, PAHs, several SVOCs, two phenolic compounds, dibutyl phthalate, total PCBs, total DDx, and other pesticides pose potentially unacceptable risk. Several other contaminants (TPH, ammonia, and sulfides) may also contribute to potentially unacceptable risk at some areas. A WOE was assessed to identify contaminants that were most likely posing unacceptable risk. Based on that evaluation, the primary COPCs in sediment that likely pose potentially unacceptable risk to the benthic community or populations are PAHs, PCBs, and total DDx. Although other contaminants may also contribute to unacceptable risk, their distribution and magnitude of risk tends to be represented by the distribution and magnitude of primary COPCs. One exception is the certain contaminants associated with the localized TZW investigation areas. In these areas, VOCs, cyanide, and perchlorate may also pose potentially unacceptable risks; however, these contaminants often co-occur with PAHs and DDx.

The phenolic compound 4-methylphenol may also be contributing to benthic community risk. The analysis conducted for the BERA shows that the sediment exposure pathway is sufficient to be of concern for 4-methylphenol. Widely distributed throughout the Study Area, this contaminant is found in both contaminated and otherwise uncontaminated areas. Methylated phenols are readily biodegraded under aerobic conditions, and 4-methylphenol is expected to have a half-life in sediment on the order of days. That 4-methylphenol was found suggests the presence of ongoing sources; however, whether and to what extent the source is degradation of historical contamination versus influx from ongoing point or non-point discharges is not known.

Sediment profile images of the surface sediment suggest that the physical environment (sediment grain size, transport regime, bottom slope) in the Study Area can explain the presence of early colonizing, transitional, and mature benthic communities in 90% of the images evaluated. In these cases, the successional stage matched the expected community structure based on the physical regime and habitat characteristics. In the vast majority of cases, mature benthic communities occurred in fine-grained depositional environments; early colonizing or transitional communities were found in less physically stable areas (for example, with steep slopes, active sediment transport, high rates of deposition, or physical disturbance). In the 31 (of 377) cases where the community successional stage was not as might be predicted by the physical environment, about two-thirds (19) occur between RM 5.0 and RM 9.0. The greatest combined area associated with potentially unacceptable risk to the benthic community was found in this same reach, suggesting possible chemical toxicity, among other potential factors, as the reason for the presence of lower successional stages. These qualitative results suggest that overall, the benthic community in the Study Area is typical of a large river system that is strongly influenced by physical processes. Impacts from sediment contamination appear to be limited to certain depositional areas that have received historical releases of contamination.

11.3.2 Fish

The fish assessment endpoints are survival, growth and reproduction of omnivorous, invertivorous, and piscivorous fish, as well as survival and growth of detritivorous fish. The assessment endpoints are based on protection and maintenance of populations and the communities in which they live, except for Pacific lamprey ammocoete and juvenile Chinook salmon, which, as special status species, are to be protected at the organism level.

Total PCBs were found to pose low risk to populations of piscivorous fish and the small-home-range invertivorous fish sculpin. Total PCB tissue-residue HQs ≥ 1 were calculated for smallmouth bass, northern pikeminnow, and sculpin samples from locations throughout the Study Area (max HQ = 9.4). HQs < 1 for juvenile Chinook salmon and peamouth show that risk to sculpin does not imply risk to invertivorous fish with larger home ranges. Together, the low Study Area-wide tissue-residue HQ of 1.6 for largescale sucker in combination with HQs < 1 for most omnivorous fish samples and with uncertainty in effects data indicate that risk to omnivorous fish is negligible.

The potential for adverse effects on all of the fish assessment endpoints from total PCBs was assessed to be low: the other LOE for PCBs—surface water—resulted in HQs < 1,[8] tissue-residue HQs ≥ 1 occurred over only a moderate spatial extent (or in relatively few samples for large-home-range fish), and uncertainty in the tissue-residue TRV is more likely to overpredict than underpredict risk. Uncertainties in the fish risk assessment are described in more detail in Sections 7.1.4, 7.2.5.1 and 7.2.5.4. ~~The tissue-residue TRV for total PCBs is conservative because it is based partially on uncertain toxicity data, including field data from contaminated sites where other contaminants were also present, suggesting that the TRV reflects toxicity from chemicals other than PCBs.~~

The spatial extent of dietary risk to juvenile Chinook salmon from cadmium encompasses a substantial portion of the Study Area. However, the assumption that juvenile Chinook consume benthic invertebrates, rather than the pelagic prey they are known to eat, overestimates exposure. The selected TRV also very likely overestimates risk because it is 3 orders of magnitude below the lowest salmon-specific NOAEL.

The spatial extent of dietary and tissue-residue risk from copper to several fish (sculpin, juvenile Chinook salmon, Pacific lamprey ammocoetes, northern pikeminnow, largescale sucker, and juvenile white sturgeon) also encompasses a substantial portion of the Study Area. The copper-fish TRVs are highly uncertain. The dietary TRV could not be replicated in subsequent studies, and the tissue-residue TRV is within the range of copper nutritional requirements for some (but not all) fish species. Furthermore, predictions of risk to fish based on tissue concentrations copper is highly uncertain because fish regulate this essential metal.

Several COPCs in TZW were identified as posing risk to individual fish~~, but not their populations~~. Benthic fish, including burrowing fish (lamprey ammocoetes) and fish that feed on benthic organsims (sculpin), have relatively low exposure to porewater compared with surface water because of their feeding habits and respiratory requirements. Risks from elevated TZW contaminant concentrations are localized to the portion of the local population exposed to the discharge area of the contaminated groundwater plumes. Portions of the local population not exposed to TZW in the groundwater discharge area are likely unaffected by the TZW contaminants. Although as TZW samples were collected from only a limited number of locations in the Study Area, the total proportion of the site with groundwater discharge into the Willamette River, as well as contaminant concentrations in TZW from any such additional areas, are unknown. For this reason concentrations of COPCs in shallow TZW likely overestimate exposure, to an uncertain degree. Because TZW exceedances are localized, ~~none~~ the potential of the TZW COPCs ~~is likely~~ to pose risk to Study Area benthic invertebrate or fish populations is also uncertain. However, 38 TZW COPCs,[9] 6 metals (barium, iron, manganese, sodium,

Comment [A8]: Recheck this count.

[8] When calculated using the alternative TRV for protection of directly exposed aquatic organisms rather than the AWQC, which is based on protection of mink through dietary exposure.

[9] Petroleum hydrocarbons were evaluated as an uncertainty and gasoline-range aliphatic hydrocarbons (C10-C12) have HQ > 10 over a limited spatial extent and also pose potentially unacceptable risk to individual lamprey.

vanadium, and zinc), 16 PAHs (2-methylnaphthalene, acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthtene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, pyrene), 2 SVOCs (1,2-dichlorobenzene, 1,4-dichlorobenzene), the pesticides 4,4′-DDT and total DDx, 10 VOCs (benzene, carbon disulfide, chlorobenzene, chloroform, cis-1,2dichloroethene, ethylbenzene, o-xylene, toluene, total xylenes and trichloroethene), cyanide and perchlorate have high concentrations in localized areas that could adversely affect Pacific lamprey ammocoetes at those locations. The magnitude of risk to individual lamprey from these COPCs is unknown however, because the TRVs were derived to be protective of the most sensitive species and are likely to overpredict risk to Pacific lamprey which has been shown to have average or lower sensitivity than most aquatic species for several chemicals causing toxicity from different modes of action (Andersen et al. 2010). Three of the 38 COPCs (excluding petroleum hydrocarbons.) with HQs > 10 are naturally occuring metals (barium, iron, and manganese) and there is substantial uncertainty as to whether their source is anthropogenic.

Risk to fish from other COPCs that resulted in HQs ≥ 1 in the final step of the risk characterization were found unlikely to result in ecologically significant adverse effects on the fish populations. The rationale for this conclusion is that TZW exposure assumptions likely overestimate risk, the TRV overestimates risk, and the great majority of samples result in HQs < 1 (indicating a limited spatial extent of potentially unacceptable risk).

11.3.3 Wildlife

The avian assessment endpoints are survival, growth, and reproduction of invertivorous, omnivorous, and piscivorous birds. The mammalian assessment endpoint was survival, growth, and reproduction of aquatic-dependent mammals. The assessment endpoints are based on protection and maintenance of populations and the communities in which they live, except for threatened or endangered species, which are to be protected at the organism level.

Total PCBs pose the primary risk. Mink and river otter HQs ≥ 1 throughout the Study Area (mink HQ = 19 to 33, river otter HQ = 21 to 31) indicate that PCBs pose ecologically significant risk of reduced reproductive success to populations of both receptors in the Study Area. While this BERA has established that PCBs pose the potential for adverse effects, the true effect of PCB exposure on Study Area populations is still unknown because of a number of uncertainties. These include quantifiable uncertainties about dietary exposure and about PCB dose-response, and quantifiable uncertainty about the level of effect associated with a population-level response. These uncertainties have not been fully examined in the BERA. The known sensitivity of mink to PCBs is demonstrated in EPA’s AWQC for PCBs, which is based on ~~protection~~dietary toxicity of bioaccumulated PCBs in prey of the aquatic-dependent mink, not on PCB toxicity to fish, aquatic invertebrates or plants. This sensitivity of mink to PCBs is likely the reason the BERA alternative water column TRV for total PCB is higher than the EPA AWQC.

Reproductive success in spotted sandpiper, bald eagle, and osprey might also be reduced because of PCB exposure, as indicated by spotted sandpiper and bald eagle HQs ≥ 1 throughout the Study Area (max HQ = 12 for sandpiper and 3.9 for eagle) and by less widespread osprey HQs ≥ 1 (max HQ = 4.4). Overall, a greater degree of uncertainty is associated with PCB risk estimates for birds than for mammals because of uncertainty about exposure and uncertainty in the effects data. Uncertainty is higher for otter than for mink because otter-specific effects data are lacking.

Total TEQ exposure also poses ecologically significant risk of reduced reproductive success to populations of mink (with HQs up to 12). Total TEQ risk to birds and otter is low, considering the WOE for eagle and osprey, the more limited spatial extent of TRV exceedances for sandpiper, and the low magnitude of HQs for river otter. PCBs are responsible for the majority of total TEQ exposure, in that PCB TEQ HQs generally constitute the majority of the total TEQ HQs. For example, mink total TEQ HQs are ≥ 1 in 16 of 109 potential prey samples; of these samples, PCB TEQ HQs are ≥ 1 in 15 samples and total dioxin/furan TEQ HQs are ≥ 1 in only 4 samples. As is the case for total PCBs, a greater degree of uncertainty is associated with total TEQ risk estimates for birds and otter than for mink because of uncertainties in both exposure and effects data for birds and uncertinaty in effects data for otter.

Osprey egg data indicate that DDx compounds pose negligible risk to osprey and low to negligible risk of reduced reproductive success to individual bald eagles within limited portions of the Study Area. The only other wildlife receptor with a DDx HQ ≥ 1 is the spotted sandpiper. DDx compounds pose negligible risk to the spotted sandpiper population because the HQs are of low magnitude, span a limited spatial extent, and based on uncertainties in exposure and effects that likely cause overestimates of risk.

The spatial extent of copper HQ ≥1 in sandpiper encompasses a large portion of the Study Area; however, risk is negligible. Only one prey item (laboratory-exposed worms) had tissue concentrations associated with an HQ ≥ 1. Copper HQs based on a mixed-species diet are < 1. Additionally, the selected TRV was below the lowest bounded literature-reported NOAEL for birds.

~~Risk to wildlife from other COPCs that resulted in HQ ≥ 1 in the final step of the risk characterization were found unlikely to result in ecologically significant adverse effects on the receptor populations because the HQs are of low magnitude, span a limited spatial extent, and are based on uncertainties in exposure and effects that likely cause an overestimate of risk.~~ The combined toxicity of dioxins/furans and dioxin-like PCBs, expressed as total toxic equivalents (TEQ), poses the potential risk of reduced reproductive success in mink, river otter, spotted sandpiper, bald eagle and osprey. The PCB TEQ fraction of the total TEQ is responsible for the majority of total TEQ exposure, but the total dioxin/furan TEQ fraction also exceeds its TRV in some locations of the Study Area.

Comment [A9]: Bald eagle risks will have to be recalculated using LOAEL TRVs in Section 8, because of the change in status of bald eagle from threatened to not threatened. The new results will have to be summarized here. For dietary dose of PCB, the LOAEL TRV is 2x the NOAEL TRV, meaning, for example, the HQ =3.9 given here will reduce to HQ = 1.9 or 2.0 depending on rounding.

Comment [A10]: Text slightly edited from LWG's executive summary, retained in EPA exec. Summary rewrite.

11.3.4 Amphibians

The amphibian assessment endpoints are survival, growth, and reproduction of amphibians. The assessment endpoints are based on protection and maintenance of populations and the communities in which they live, except for threatened or endangered species, which are to be protected at the organism level. For all COPCs with HQs ≥ 1, the risk to amphibian populations was assessed to be negligible. COPCs in surface water samples resulting in HQ ≥ 1 were found at concentrations below amphibian-specific thresholds or were collected during non-reproductive periods (when amphibians may not be present in the Study Area). For the TZW LOE, the great majority of samples result in HQs < 1, indicating limited spatial extent of exceedance. Although risk to amphibians from TZW is highly uncertain, it is likely to be negligible because significant exposure to Study Area TZW by this receptor group is unlikely.

11.3.5 Aquatic Plants

The aquatic plant assessment endpoints are survival, growth, and reproduction of aquatic plants. The assessment endpoints are based on protection and maintenance of populations and the communities in which they live, except for threatened or endangered species, which are to be protected at the organism level.For all COPCs with HQs ≥ 1, the risk to aquatic plant populations was assessed to be negligible. The same COPCs whose surface water HQ is ≥ 1 were found in the great majority of samples to have HQ < 1 and at concentrations generally below algae-specific thresholds. For the TZW LOE, the great majority of samples result in HQs < 1, indicating limited spatial extent of exceedance.

11.3.6 Potential Future Risks to the Benthic Community

Risk to the benthic community was assessed both for current conditions in the Study Area and estimated future conditions. The future condition assessment is based on the maximum bed change scenario presented in the draft RI (Map 3.4-7) and a sample-by-sample evaluation of changes in status of predicted risk in the erosional areas based on comparison to site-specific SQVs. Attachment 18 presents the approach and results of the current and future risk predictions in the erosional areas of the Study Area. For the majority of erosional sediments (approximately 60%), there was no change of status in predicted risk to the benthic community (i.e., the sediment quality was similar at the erosional depth and the surface). This finding is not surprising because the erosional sediments are predicted to be primarily sands. Of the remaining erosional sediments, approximately 24% is predicted to be more contaminated in the future. The last 16% of the erosional area is predicted to be cleaner after the erosional event.

12.0 RISK MANAGEMENT RECOMMENDATIONS

This section presents the LWG's ecological risk management recommendations to develop and evaluate remedial alternatives that are protective of ecological resources. Risk management recommendations are provided in four main parts:

- Section 12.1 presents recommended COCs for populations of fish and wildlife receptors.[10]
- Section 12.2 presents recommendations regarding contaminants present in TZW. TZW risk management recommendations are presented separately from those for other exposure media because the TZW LOE focuses on a spatially limited set of nine TZW sampling areas; the other exposure media (sediment, tissues, and surface water) were evaluated Study Area-wide. Furthermore, the TZW sampling areas were selected to capture information at locations with known or likely pathways for ongoing sources (discharge of upland contaminated groundwater), whereas the other exposure media were investigated because they represent complete exposure pathways to ecological receptors from contaminated sediment. Thus, both the nature and extent of risk as well as the alternatives for addressing them are unique for TZW.
- Section 12.3 presents risk management recommendations for protection of the benthic invertebrate community. As the BERA's benthic risk conclusions rely heavily on LOEs that do not identify specific COPCs (i.e., empirical measurements of sediment toxicity, predictions of sediment toxicity based on multivariate statistical models, and benthic community data from SPI imagery), this section recommends methodologies for delineating benthic AOCs and for evaluating the degree to which remedial action alternatives protect the benthic community.
- Section 12.4 summarizes the risk management recommendations.

12.1 Recommendation of COCs for Study Area Populations of Fish and Wildlife Receptors

In this section, the entire set of contaminants identified as posing potentially unacceptable risk to fish and wildlife receptors is evaluated. The purpose of the evaluation is to identify the COPCs for fish and wildlife receptors to use in the FS to develop and evaluate remedial alternatives that are protective of ecological resources. This subset of COPCs constitutes the recommended COCs.

As discussed in Section 3, the assessment endpoints for most of the ecological receptors identified in EPA's Problem Formulation are for protection of the populations of fish, birds, mammals, and amphibians, and for protection of communities of benthic invertebrates and aquatic plants. The exceptions are that assessment endpoints for special

[10] Where secondary benthic LOEs support these recommendations for fish and wildlife receptors, they are identified.

status species identified in EPA's Problem Formulation (i.e., bald eagle, juvenile Chinook salmon, and Pacific lamprey ammocoetes) are for protection at the level of the organism.

The COC recommendations provided in this section are intended to address Study Area-wide risks to receptor populations. These recommendations are also intended to be protective of the aquatic plant community and receptors assessed at the organism level, except risk to Pacific lamprey ammocoetes from TZW exposure. Recommendations regarding risks from exposure to contaminants posing potentially unacceptable risk in TZW are presented in Section 12.2. Recommendations regarding identification of benthic risk areas and related protectiveness are provided in Section 12.3.

The remainder of Section 12.1 is presented in three main parts:

- Section 12.1.1 presents the rationale for COC recommendations.
- Section 12.1.2 applies that rationale to recommend COCs.
- Section 12.1.3 provides additional recommendations for the contaminants posing potentially unacceptable risk that are recommended as COCs. This includes recommendations about which receptors of concern should be considered along with the COCs to assess the protectiveness of potential remedies in the FS analysis of alternatives.

12.1.1 Rationale for COC Recommendations

COCs will be used to develop and evaluate remedial alternatives that are protective of ecological resources. The FS will also evaluate whether remedial alternatives for these COCs address the full list of contaminants posing potentially unacceptable risk.

The COC recommendations took into account one or more of the following factors:

- How often, where, and in which media risk thresholds were exceeded
- The ecological relevance (strengths and weaknesses) of the exposure estimates used to calculate HQs
- The toxicological effects associated with the TRV
- The magnitude of the exceedance
- Whether a relationship was found between COPC concentrations in co-located sediment and tissue concentrations (for small-home-range species)
- The relative strength and concordance among LOEs used to evaluate risks
- Comparison of Study Area concentrations with available background or upriver data

Some of these factors are strongly risk-based (e.g., the toxicological effects associated with the TRV, and the relative strength and concordance among LOEs), whereas others are more directly related to practical FS considerations (e.g., whether a relationship was found between COPC concentrations in co-located sediment and tissue concentrations for small-home-range species, and comparison with available background or upriver data).

12.1.2 COC Recommendations

Table 12-1 summarizes the contaminants posing potentially unacceptable risk in this BERA and whether they are recommended as COCs for fish and wildlife receptors. Contaminants posing potentially unacceptable risk based on the TZW LOE are discussed in Section 12.2. Areas and contaminants posing potentially unacceptable risk to the benthic community are discussed in Section 12.3; however, where benthic tissue-residue and surface water LOEs support the selection of COCs for protection of fish and wildlife, they are noted. Nineteen COPCs with at least one HQ ≥ 1 have been identified in this BERA for fish and wildlife receptors.[11,12] The set consists of seven metals, two butyltins, three PAHs, two phthalates, PCBs, dioxins/furans, two pesticides, and one VOC. The specific rationale for COC recommendations—based on the seven factors identified in Section 12.1—follows Table 12-1.

Table 12-1. COC Recommendations for All Receptor Group-LOE Pairs with an HQ ≥ 1

COPC	Receptor Group-LOE Pairs Resulting in HQ ≥ 1
Contaminants Recommended as COCs	
PCBs	
Total PCBs	Benthic invertebrate – tissue residue (clam, worm)
	Fish – tissue-residue (sucker, sculpin, bass, pikeminnow)
	Mammal – diet (mink, river otter)
	Bird – diet (sandpiper, osprey, bald eagle, merganser)
	Bird – tissue-residue (osprey, bald eagle)
Dioxins/Furans	
Total TEQ[a]	Mammal – diet (mink, river otter)
	Bird – diet (sandpiper)
	Bird – tissue residue (osprey, bald eagle)
Contaminants Not Recommended as COCs	
Inorganic Metals	
Aluminum	Mammal – diet (mink)

[11] PCB TEQ and dioxin/furan TEQ are not included in this count because they are components of the total TEQ.

[12] Risk management recommendations for the benthic community assessment endpoints and the TZW LOE are handled separately and are not included in this COPC count.

Table 12-1. COC Recommendations for All Receptor Group-LOE Pairs with an HQ ≥ 1

COPC	Receptor Group-LOE Pairs Resulting in HQ ≥ 1
Antimony	Fish – tissue residue (bass)
Arsenic	Benthic invertebrate – tissue residue (worm)
Cadmium	Fish – diet (sculpin, Chinook)
Copper	Benthic invertebrate – tissue residue (clam, crayfish, worm)
	Fish – diet (sucker, sturgeon, Chinook, peamouth, sculpin, pikeminnow)
	Fish – tissue-residue (sculpin, Chinook, lamprey, pikeminnow)
	Birds – diet (sandpiper)
Lead	Fish – tissue-residue (peamouth, bass)
	Birds – diet (osprey)
	Mammals – diet (mink)
Zinc	Benthic invertebrates – surface water, benthic invertebrate tissue residue (clam, mussel, worm)
	Fish – surface water (sculpin, bass, pikeminnow)
	Amphibians – surface water
	Aquatic plants – surface water
Organometals	
Mercury	Fish – diet (sculpin)
Monobutyltin	Benthic invertebrates – surface water
	Fish – surface water (sculpin, bass, pikeminnow)
	Birds – diet (bald eagle)
TBT	Benthic invertebrate (clam and worm tissue residue)
	Fish – diet (sculpin)
PAHs	
Benzo(a)anthracene	Benthic invertebrates – surface water
	Fish – surface water (sculpin, bass, pikeminnow)
	Amphibians – surface water
	Aquatic plants – surface water
Benzo(a)pyrene	Benthic invertebrates – surface water
	Fish – surface water (sculpin, bass, pikeminnow)
	Birds – diet (sandpiper)
	Amphibians – surface water r
	Aquatic plants – surface water

Table 12-1. COC Recommendations for All Receptor Group-LOE Pairs with an HQ ≥ 1

COPC	Receptor Group-LOE Pairs Resulting in HQ ≥ 1
Naphthalene	Benthic invertebrates – surface water
	Fish – surface water (sculpin, bass, pikeminnow)
	Amphibians – surface water
	Aquatic plants – surface water
Phthalates	
BEHP	Benthic invertebrates – surface water, tissue residue (worms)
	Fish – tissue residue (sculpin, bass,)
	Fish – surface water (sculpin, bass, pikeminnow)
	Amphibians – surface water
	Aquatic plants – surface water
Dibutyl phthalate	Birds – diet (sandpiper)
Pesticides	
Aldrin	Birds – diet (sandpiper)
Total DDx[b]	Benthic invertebrates – surface water, tissue residue (clam, worm)
	Fish –tissue residue (sculpin)
	Fish – surface water (sculpin)
	Birds – diet (sandpiper)
	Birds – tissue residue (bald eagle)
	Amphibians – surface water
	Aquatic plants – surface water
4,4′-DDD	Benthic invertebrate – tissue residue (worms)
VOCs	
Ethylbenzene	Benthic invertebrates – surface water
Trichloroethene	Benthic invertebrates – surface water
	Fish – surface water (sculpin)

[a] Total TEQ includes risk estimates for PCB TEQ and total dioxin/furan TEQ.

[b] Total DDx includes risk estimates for the additional DDx components that were also evaluated independently (sum DDE, 4,4′-DDE, and 4,4′-DDT). Risk estimates for the surface water LOE are based on the alternative 4,4′-DDT TRVs for protection of directly exposed aquatic organisms, rather than the AWQC-based TRV. The alternative TRV is considered more appropriate for evaluating direct exposure of aquatic organisms because the AWQC is based on protection of dietary risks to birds.

AWQC – ambient water quality criterion
BEHP – bis(2-ethylhexyl) phthalate
COC – contaminant of concern
COPC – contaminant of potential concern
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
SVOC – semivolatile organic compound
TBT – tributyltin

DDD – dichlorodiphenyldichloroethane
DDE – dichlorodiphenyldichloroethylene
DDT – dichlorodiphenyltrichloroethane
HQ – hazard quotient
LOE – line of evidence
TEQ – toxic equivalent
total DDx – sum of all six DDT isomers (2,4′-DDD, 4,4′-DDD, 2,4′-DDE, 4,4′-DDE, 2,4′-DDT, and 4,4′-DDT)
TRV – toxicity reference value
VOC – volatile organic compound

12.1.2.1 Recommended COCs

PCBs

Total PCBs is recommended as a COC because exposure poses a risk of ecologically significant adverse effects to mink and river otter populations. It also poses risk of ecologically significant adverse effects to spotted sandpiper, osprey, sculpin, and smallmouth bass populations and risk of adverse effects to bald eagles.The benthic tissue-residue LOE also supports the selection of PCBs as a COC. These additional risks are lower than the risk to mink and river otter populations. Further risk management recommendations regarding total PCBs are provided in Section 12.1.3.

Dioxins/Furans

Total TEQ is recommended as a COC because exposure poses a risk of ecologically significant adverse effects to mink populations. Total TEQ also poses risk of adverse effects to river otter, spotted sandpiper, and osprey populations and to bald eagles. These latter risks are lower than the risk to the mink population. Further risk management recommendations regarding dioxins/furans are provided in Section 12.1.3.

12.1.2.2 COPCs Not Recommended as COCs

Inorganic Metals

None of the seven metals with HQ $\geq$ 1 is recommended as a COC for assessing potential remedy protectiveness of ecological receptors. The rationales for exclusion are as follows:

- Aluminum poses potentially unacceptable risk only for mink. For the following reasons, it is not recommended as a COC:
  - Aluminum exceeds the dietary TRV only based on sediment ingestion, no prey samples exceed the effects threshold.
  - TRV is based on exposure of mice to a highly soluble ionic form of aluminum with higher bioavailability than typically found in the diet or drinking water.
  - Study Area sediment and surface water concentrations are similar to background.
- Antimony poses potentially unacceptable risk based only on the tissue-residue LOE for smallmouth bass. For the following reasons, it is not recommended as a COC:
  - Low frequency of TRV exceedance (1 of 32 [3.1%] smallmouth bass samples)

- Weakness of the exposure estimate (the single composite sample is an outlier for both antimony and lead, suggesting that a fish in the sample might have swallowed a fishing sinker)[13]
- Weakness of the effects estimate (TRV is based on a single study with a generic ACR applied)
- Absence of relationship between concentrations in sediment and co-located tissue samples (Windward 2009b)

- Discordance between the weaker tissue-residue LOE and the stronger surface water LOE (surface water TRV based on numerous exposure data and moderately sized Tier II effects dataset). Arsenic poses potentially unacceptable risk to benthic invertebrates based only on the tissue-residue LOE. It is not recommended as a COC for two reasons:
  - Low frequency of exceedance of the TRV (2 of 35 samples)
  - Low magnitude of the exceedance (maximum HQ = 1.5)
- Cadmium poses potentially unacceptable risk based only on the dietary LOE for juvenile Chinook salmon and sculpin. For the following reasons, it is not recommended as a COC:
  - Low frequency of TRV exceedance in sculpin prey samples (9 of 111 [8.1%] prey samples, with maximum HQ = 2.2; and 1 of 1,348 [< 0.1%] sediment samples)
  - Weakness of the Chinook exposure estimate (juvenile Chinook were conservatively presumed to feed predominantly on benthic organisms; this feeding strategy is contrary to the literature, which shows they feed predominantly on pelagic organisms)
  - Uncertainty about the toxicological effects associated with the TRV (rockfish LOAEL setting the TRV is 2 to 3 orders of magnitude below the nine NOAELs from other studies, including four NOAELs and two LOAELs for salmonids)
  - Low magnitude of juvenile Chinook salmon dietary HQ (3.5 assuming mixed prey diet) when taking into account the likelihood that both exposure and effects are overestimated (per the two previous items)
  - Discordance of the dietary LOE with the surface water and tissue-residue LOEs (the cadmium AWQC is based on a very large dataset so is the strongest LOE; the tissue-residue LOE is weak because fish sequester or otherwise bioregulate inorganic metals)

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[13] Antimony can be mixed with lead as a hardener for lead-based products (ATSDR 1992). For example, one fish tackle supplier notes that fishing sinkers contain 94% lead and 6% antimony for hardness and color (Blue Ocean Tackle 2011).

- Copper poses potentially unacceptable risk based on the fish tissue-residue, fish dietary, sandpiper dietary, and the benthic invertebrate tissue-residue LOEs. For the following reasons, copper is not recommended as a fish COC:

  – Weakness of the tissue-residue LOE for inorganic metals (fish can actively bioregulate copper tissue concentrations; invertebrates sequester copper and in the case of crayfish, copper forms the basis of their hemoglobin)

  – Irreproducible toxicological effects associated with the dietary TRV (selected LOAEL could not be replicated in subsequent tests with the same species)

  – Selected LOAEL is barely above range of nutritional requirements found in the literature for some fish species

  – Discordance of the tissue and dietary LOEs with the stronger water LOE (which is based on numerous exposure data and a very large AWQC dataset showing that fish are not among the most sensitive species; absence of HQ ≥1 via the water LOE is the strongest evidence for drawing risk conclusions)

  – Similarity of fish tissue concentrations in the Study Area and upriver

  For the following reasons, copper is not recommended as a shorebird COC:

  – Unlikely ecological significance of prey organism TRV exceedance (tissue-residue HQ ≥ 1 in only one prey item, laboratory-exposed worms; HQs < 1 for a mixed-species diet).

  – The selected TRV is less than the lowest bounded literature-reported NOAEL for birds.

  – Low magnitude of TRV exceedance (maximum HQ = 1.3) considering the likely overestimates of exposure and effects (per the two previous items)

  For the following reasons, copper is not recommended as a benthic invertebrate COC:

  – Low magnitude of TRV exceedance (maximum HQ = 2.6)

  – Weakness of the tissue-residue LOE for inorganic metals (invertebrates sequester copper and in the case of crayfish, copper forms the basis of their hemoglobin)

- Lead poses potentially unacceptable risk based on the tissue-residue LOE for peamouth and smallmouth bass, and on the dietary LOE for osprey and mink. It is not recommended as a fish COC for the following reasons:

  – Low frequency of tissue TRV exceedance (2 of 32 [6.2%] smallmouth bass and 1 of 4 [25%] peamouth samples)

  – Weakness of the exposure estimate (smallmouth bass concentration yielding high HQ [280] is an outlier for both antimony and lead in the same sample, suggesting that a fish in the composite sample might have swallowed a fishing sinker)

  - Discordance of tissue-residue LOE with dietary and water LOEs (based on a very large dataset, the lead AWQC is the strongest LOE; the tissue-residue LOE is weak because fish generally can sequester or otherwise bioregulate inorganic metals; the dietary LOE is more likely to overpredict than underpredict risk)

  Lead is not recommended as a bird or mammal COC because the only sample yielding an HQ ≥ 1 is the same outlier smallmouth bass sample as identified for antimony above

- Zinc poses potentially unacceptable risk for fish (sculpin, bass, pikeminnow), amphibians, and aquatic plants based only on the surface water LOE. It poses a potentially unacceptable risk to benthic invertebrates based on the surface water and tissue-residue LOEs. It is not recommended as a COC for the following reasons:
  - Low frequency of surface water TRV exceedance for all receptors (1 of 167 samples [< 1%], with maximum HQ = 1.2)
  - Discordance of the stronger surface water LOE with the weaker tissue-residue and dietary LOEs for fish (surface water toxicity data were sufficient to derive AWQC; tissue-residue LOE is weak because fish generally can sequester or otherwise bioregulate inorganic metals; the dietary LOE is relatively weak because the TRV is based on only two studies)
  - The tissue-residue LOE for benthic invertebrates is a weak LOE

Organometals

- Mercury poses potentially unacceptable risk based on the dietary LOE for sculpin and bald eagle. It is not recommended as a fish COC because the dietary TRV was exceeded in only 1 of 1,345 sediment samples (< 0.001%) and in no tissue samples. Mercury is not recommended as an eagle COC for the following reasons:
  - Discordance between the dietary and tissue-residue LOEs
  - Possible overestimate of bald eagle exposure when using osprey exposure as a surrogate because of greater proportion of terrestrial prey in the bald eagle diet
  - Low HQ (maximum HQ = 1.7) given the discordant LOEs and possibility that exposure is overestimated (per the previous two items)
  - Higher concentrations in upriver fish tissue than in Study Area fish tissue
- Monobutyltin poses potentially unacceptable risk based on the surface water LOE. It is not recommended as a COC for three reasons:

- Low frequency of surface water TRV exceedance (1 of 167 samples [< 1%])
- Likely overestimate of toxicological effects associated with the TRV (which is based on the more toxic TBT)
- Low magnitude of exceedance (HQ = 1.2) considering the likely overestimate of effects and limited spatial extent of HQ ≥ 1 (per the previous two items)

- TBT poses potentially unacceptable risk based on the dietary LOE for sculpin and tissue-residue LOE for benthic invertebrates. It is not recommended as a COC for fish for the following reasons:
  - Single dietary TRV exceedance (based on 1 lab worm sample of 81 prey samples [1.2%] and only when combined with sediment ingestion)
  - Low magnitude of exceedance (maximum HQ = 1.0)
  - Uncertainty about toxicological effects associated with the TRV (reproduction success was reduced at the TRV, but not dose-responsive)
  - Discordance of dietary LOE with the tissue-residue and water LOEs (TBT tissue residue is noted to be reliable predictor of toxicity and is the strongest LOE(Meador et al. 2002a))

  It is not recommended as a COC for benthic invertebrates because of the following:
  - The TRV was exceeded in empirical bioaccumulation samples only at one location.
  - While predicted tissue residues exceeded the TRV more frequently, the moderate strength of the regression was highly influenced by the one high value in the dataset. The predicted tissue residues are uncertain and not supported by empirical data.
  - The TRV is uncertain due to the inclusion of imposex—the endpoint that defined the lower distribution of the SSD, which set the TRV

***PAHs*[14]**

Benzo(a)anthracene, benzo(a)pyrene, and naphthalene pose potentially unacceptable risk to benthic invertebrates, fish, amphibians, and aquatic plants based on the surface water LOE. Benzo(a)pyrene poses potentially unacceptable risk to spotted sandpiper based on the dietary LOE. None of these three individual PAHs is recommended as a COC for assessing potential remedy protectiveness of ecological receptors.[15]

[14] Risk management recommendations regarding PAHs as they relate to risks from the TZW LOE and benthic AOCs are discussed separately in Sections 12.2 and12.3, respectively.

[15] In the TZW LOE, however, concordance of surface water and TZW exceedances at RM 6.4 to RM 6.5 supports identification of benzo(a)anthracene, benzo(a)pyrene and naphthalene as COCs for this location (see Section 12.2).

- Benzo(a)anthracene is not recommended as a COC for two reasons:
  - Low frequency of surface water TRV exceedance (2 of 245 samples [< 1%], both between RM 6.4 and RM 6.5[16]
  - Discordance of surface water LOE with dietary LOE for fish (benzo(a)anthracene did not screen in as a fish COPC by the dietary LOE)
- Benzo(a)pyrene is not recommended as a COC based on the surface water LOE for two reasons:
  - Low frequency of surface water TRV exceedance (3 of 122 [2.4%] near-bottom surface water samples, all from RM 6.4 to RM 6.5)[17]
  - Discordance of the surface water LOE with the dietary LOE for fish (benzo(a)pyrene did not screen in as a fish COPC by the dietary LOE)
- Benzo(a)pyrene is not recommended as a COC based on the bird dietary LOE for two reasons:
  - Low frequency of dietary TRV exceedance for spotted sandpiper (1 of 27 [3.7%] lab worm samples assuming lab worm-only diet; all HQs < 1 for clam-only diet)
  - Low magnitude of exceedance (maximum HQ = 1.6) considering potential overestimate of exposure by presuming lab worm-only diet
- Naphthalene is not recommended as a COC for two reasons:
  - Low frequency of surface water TRV exceedance (10 of 268 [3.7%] samples, all from west side of RM 6.4 to RM 6.5 during a single sampling event [the May 2005 non-LWG sampling event])[18]
  - Discordance of the surface water LOE with the dietary LOE for fish (naphthalene did not screen in as a fish COPC by the dietary LOE)

Phthalates

Neither of the two phthalates is recommended as a COC:

- BEHP poses potentially unacceptable risk based on the benthic invertebrate and fish tissue-residue and surface water LOEs. It is not recommended as a COC for several reasons:

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[16] In the TZW LOE, however, concordance of surface water and TZW exceedances at this sampling location support identification of benzo(a)anthracene as a COC for this location (see Section 12.2).

[17] In the TZW LOE, however, concordance of surface water and TZW exceedances at this sampling location support identification of benzo(a)pyrene as a COC for this location (see Section 12.2).

[18] In the TZW LOE, however, concordance of surface water and TZW exceedances at this sampling location support identification of naphthalene as a COC for this location (see Section 12.2).

- Low frequency of surface water TRV exceedance (2 of 190 samples [1.1%])
- Low frequency of fish tissue-residue TRV exceedance (1 of 38 sculpin samples [2.6%], 2 of 32 smallmouth bass samples [6.3%]) and low frequency of the benthic invertebrate tissue-residue TRV exceedance (1 of 35 clam samples or 3%)
- Low magnitude of exceedance for fish tissue TRV (maximum HQ = 2.9) and for benthic invertebrate TRV (maximum HQ = 2.8)
- Absence of toxicological effects associated with the tissue TRV (which is based on an unbounded NOAEL)
- Absence of relationship between concentrations in co-located sediment and tissue samples

- Dibutyl phthalate poses potentially unacceptable risk based on the dietary LOE for spotted sandpiper. It is not recommended as a COC for several reasons:
  - Low frequency of dietary TRV exceedance (1 of 28 clam samples [3.6%], no worm samples)
  - Low magnitude of dietary TRV exceedance (maximum HQ = 1.4 for clam-only diet; maximum HQ < 1 for worm-only diet)
  - Absence of a relationship between concentrations in co-located sediment and tissue samples
  - Higher sediment concentrations in background than in Study Area

Pesticides

None of the three organochlorine pesticides is recommended as a COC for assessing potential remedy protectiveness of ecological receptors:

- Aldrin poses potentially unacceptable risk based on the dietary LOE for spotted sandpiper. It is not recommended as a COC for two reasons:
  - Low frequency of dietary TRV exceedance (1 of 27 lab worm samples [3.7%])
  - Low magnitude of exceedance (maximum HQ = 1.4 based on the only lab worm sample that yields an HQ ≥ 1; HQ < 1 for clam-only and mixed diets)
- Total DDx poses potentially unacceptable risk based on the tissue-residue LOE for sculpin and benthic invertebrates; the dietary LOE for spotted sandpiper; the egg LOE for bald eagle; and the surface water LOE for the benthic community, sculpin, amphibians, and aquatic plants. The rationale for exclusion from the list

of recommended COCs varies with LOE.[19] DDx is not recommended as a COC for the following reasons:

- Low frequency of TRV exceedance (1 of 170 samples [<1%]) in surface water based on N-qualified data, indicating interference from another analyte
- Low frequency of exceedance in empirical benthic tissue residue (2 of 35 worm samples or 6%)
- Low frequency of exceedance in predicted benthic tissue residues (up to 15 samples of 1,128 or 1.3%) and approximately half of which are based on N-qualified data
- Low frequency of TRV exceedance (2 of 27 lab worm samples [7.4%]) used in the dietary LOE for sandpiper
- Low magnitude of exceedance of TRV for sandpiper diet (maximum HQ = 1.4 assuming lab worm-only diet; HQ < 1 for all clam-only and mixed diets)
- Questionable relevance of estimated exposure for the bird egg LOE for bald eagle (there is significant uncertainty about the source of DDx residues in the osprey eggs collected from the Study Area because the adults overwinter in Mexico and Central America, nesting and laying eggs shortly after returning to the lower Willamette (Henny et al. 2004)
- Potential risk of adverse effects on bald eagles is present because NOAEL HQs are ≥ 1 in eggs from two of five exposure areas;because both were below the LOAEL, there is no empirical evidence of potential risk.
- All egg total DDx concentrations were below the recommended effects threshold reported in Elliott and Harris (2001\2002) based on a comprehensive review of the available bald eagle toxicological effects data
- Absence of relationship between concentrations in osprey egg samples and nearby sediment (NOAEL HQ ≥ 1 in eggs from two of five exposure areas, but NOAEL HQ < 1 in eggs from where sediment DDx concentrations were highest)
- Discordance of LOEs (mixed species dietary NOAEL HQs < 1 in all exposure areas)

• 4,4′-DDD poses potentially unacceptable risk based on the tissue-residue LOE for benthic invertebrates. This contaminant is not recommended as a COC for the following reasons:

  - Low frequency of TRV exceedance (1 of 35 samples or < 3%)

[19] Total DDx and 4,4′-DDT are recommended as TZW COCs in the TZW sampling area at ~ RM 7.4W (see Section 12.2).

– Low magnitude of the exceedance (HQ = 1.2)

VOCs

Two VOCs (ethylbenzene and trichloroethene) measured in surface water exceeded their respective TRVs; however, neither is recommended as a COC based on the following rationale:

- Low frequency of exceedance; TRV exceeded in 1 of 23 (4%) samples collected from ~ RM 6.5 (west bank) during one sampling event
- Low magnitude of exceedance of the TRV for ethylbenzene (HQ = 1.6)

12.1.3 Risk Management Recommendations for Recommended COCs

Based on the information presented in Section 12.1, total PCBs and total TEQ pose the primary risks to fish and wildlife. The remainder of this section provides additional risk management recommendations for these recommended COCs:

- Section 12.1.3.1 recommends the use of mink to evaluate total PCB and total TEQ remedies.
- Section 12.1.3.2 examines relationship between PCB and TEQ risk.
- Section 12.1.3.3 discusses potential problems with the use of the bird egg LOE as an evaluation tool for potential remedies.

12.1.3.1 Receptors of Concern for Purposes of Assessing the Protectiveness of Potential Remedies in the FS Analysis of Alternatives

Total PCBs is recommended as a COC because exposure poses a risk of ecologically significant adverse effects to mink and river otter populations. Total PCBs also poses lower risk of ecologically significant adverse effects to benthic invertebrates, spotted sandpiper, osprey, sculpin, and smallmouth bass populations and to bald eagles. Total TEQ is recommended as a COC because exposure poses a risk of ecologically significant adverse effects to mink populations. Total TEQ also poses lower risk of adverse effects to river otter, spotted sandpiper, and osprey populations and to bald eagles.

For the dietary LOE, HQs are a function of food and sediment ingestion rates relative to the organism's body weight, the COPC concentrations in prey and sediment, and the TRV. Of the receptors at risk from PCBs and total TEQ via the dietary LOE, mink has the lowest TRVs. The bird PCB LOAEL TRV is higher than that of mink by a factor of 16, and the bird total TEQ LOAEL TRV is higher than that of mink by a factor of 64, indicating that risk to mink occurs at lower dietary doses.

Given the same sediment and prey data, dietary risk estimates for mink will always be higher and more widespread than those for the other receptors. Food and sediment ingestion rates as a function of body weight are higher for mink than for otter; and they are higher for birds than for mink (by a factor ranging from 1.3 for osprey to 7 for spotted sandpiper). However, the difference in TRVs (for both total PCBs and total TEQ) more than offsets the difference in ingestion rates. Although a mink population is not known to be present in the Study Area, mink are assumed to forage in all areas of the Study Area and to prey on small- and large-home-range fish. Analysis of remedial alternatives for mink will thus be protective of other receptors in the Study Area potentially affected by PCBs and dioxins.

Predicted mink risk is based on species-specific effects data, making mink risk predictions a relatively strong basis for risk management decisions. This is not the case for the other receptors (predicted risks are not based on species-specific effects data), whose conclusions therefore provide a less certain basis for risk management recommendations. Because the available data suggest that mink are quite sensitive to PCBs and dioxins/furans, and probably more so than the other receptors at risk, the mink population should be the receptor of concern when assessing ecological risk reduction for the remedial alternatives (for total PCBs and total TEQ).

Because protection of other receptors by mink is contingenent on the habitat use, prey, and home-range assumptions used for the BERA, any alteration of these assumptions for analysis of uncertainties in the FS should be examined to ensure that protection of all receptors at risk from PCBs and TEQ are still protected under alternate assumptions for mink.

Because the relationship between sediment contamination and bird egg tissue concentrations is highly uncertain, the tissue-residue LOE has limited utility as a tool for assessing the protectiveness of potential remedies in the FS analysis of alternatives. This is discussed further in Section 12.1.3.3.

12.1.3.2 Relationship Between PCB and TEQ Risk

Total TEQ is the sum of multiple PCB and dioxin/furan congeners, each weighted by their toxicity relative to that of the most toxic congener (2,3,7,8-TCDD). TEQ concentrations for birds and mammals were calculated as the sum of individual PCB and dioxin/furan congener concentrations weighted by their TEFs. The PCB TEQ is the TEF-weighted sum of only the dioxin-like PCB congener concentrations, the total dioxin/furan TEQ is the TEF-weighted sum of only the dioxin/furan congener concentrations, and total TEQ is the sum of the PCB TEQ and the total dioxin/furan TEQ. TEF values for a given congener generally fall within a range of about an order of magnitude for mammals (Sanderson and Van den Berg 1999); TEFs for birds are more uncertain (Van den Berg et al. 1998). Because of this uncertainty, TEQ risks may be over- or underestimated.

As with total PCBs, mink is the receptor most sensitive to dioxins/furans and subject to the greatest spatial extent of TEQ risk in the Study Area. PCBs are responsible for the majority of total TEQ risk, in that PCB TEQ HQs generally constitute the majority of the total TEQ HQs. For example, of the 15 (out of 109) potential prey samples with mink total TEQ HQ ≥ 1, 7 exceed the TRV for PCB TEQ but only 4 exceed the TRV for total dioxin/furan TEQ (see Attachment 17). No individual samples result in an exceedance of both the PCB TEQ TRV and the dioxin/furan TEQ.

Because total TEQ risk is largely driven by PCB, and redundant with total PCB risk (with the four exceptions noted above), and because adverse effects in mink are better correlated with total PCB exposures than with TEQ exposures (Fuchsman et al. 2007), the FS analysis of alternatives should focus primarily, but not exclusively, on evaluating whether remedies protect the mink population from risk due to exposure to total PCBs.

12.1.3.3 Bird Egg LOE and the FS

PCBs and total TEQ pose low risk to birds based on the tissue-residue LOE. It is recommended that the bird egg LOE not be used to develop and evaluate remedial alternatives in the FS. Risk to osprey and bald eagle based on the egg LOE cannot be directly compared with dietary risks. Egg tissue concentrations might reflect exposure to contaminated prey from the Study Area. Alternatively, inasmuch as osprey lay eggs shortly after returning to the Study Area from overwintering in Mexico and Central America, the egg residues might reflect exposure to contaminants outside of the Study Area. Furthermore, the bioaccumulation relationship from prey to egg is not well-characterized, rendering predictions based on this relationship highly uncertain.

A statistical evaluation was conducted to determine if a relationship between fish tissue and bird egg tissue concentrations in the Study Area could be expressed using biomagnification regressions (BMRs). A BMR expresses the relationship between fish prey and bird egg tissue concentrations based on co-located data rather than based on an average ratio. BMRs were calculated based on the method by Burkhard (2009) using co-located (within 1 mile) composite fish tissue and egg concentrations from seven locations throughout the Willamette River (Henny et al. 2003; 2009). Several possible linear tissue-sediment models were screened. No significant relationship (i.e., no BMR) could be found for any bird egg COPC based on the the criteria of a significantly positive slope at a $p = 0.05$ and an $r^2 > 0.030$, except total TEQ ($r^2 = 0.52$). For total TEQ, application of the BMR to the Study Area requires extrapolation outside of the dataset, thus rendering the relationship uncertain. The implication is that the available dataset is insufficient to estimate a reliable BMR.

Because mink is the receptor most sensitive to PCBs and dioxins/furans, it is recommended that from an ecological risk management perspective, FS analyses should focus primarily on the mink dietary risk reduction associated with the remedial alternatives.

12.2 TZW RISK MANAGEMENT RECOMMENDATIONS

The TZW LOE was used to assess risks to benthic invertebrate, benthic fish (i.e., sculpin and lamprey ammocoetes), aquatic plant, and amphibian populations and communities. Pacific lamprey are identified in EPA’s Problem Formulation as a “species of special concern” with direction to assess risk at the organism level. Measured TZW concentrations exceed water TRVs in all of the TZWsampling areas; by EPA’s direction individual lamprey ammocoetes are exposed to potentially unacceptable risk. The degree to which TZW poses potentially unacceptable risk to individual lamprey ammocoetes is uncertain. Lamprey ammocoete toxicity testing has demonstrated their relative insensitivity to toxicants across six modes of action (Andersen et al. 2010). It is probable that the BERA overestimates both lamprey ammocoete exposure and effects, to an unquantified degree.

The TZW samples evaluated in this assessment were collected primarily during a 2005 sampling effort focused offshore of nine[20] upland sites with known or likely pathways for discharge of upland contaminated groundwater. The primary objective of the RI groundwater pathway assessment was to evaluate whether transport pathways from upland contaminated groundwater plumes to the river were complete. Therefore, TZW target analyte lists varied from site to site and were derived primarily based on the COIs in the upland contaminated groundwater plumes. Consequently, not all COIs in sediments were analyzed in TZW samples. As described in Sections 4.4.3.1 and 6.1.5.2 of the draft final RI (Integral et al. 2011), there also might be other groundwater plumes in the Study Area discharging into river sediments where TZW samples have not been collected.

TZW sampling focused on sites with contaminated groundwater pathways that were a potential concern. Where these groundwater pathways are confirmed to be a concern, they will be addressed through source control. Source controls should be in place prior to implementation of sediment remedies, particularly those associated with upland sources (EPA 2002b, 2005a) in order to prevent recontamination. These source control actions will reduce contaminant flux to the river and accelerate recovery. Source controls will reduce baseline risk by intercepting ongoing contaminant migration. While the residual contaminated groundwater plumes may remain near the mudline, they will attenuate over time. Because source controls should precede the sediment remedy, the magnitude of potential risk identified in the BERA should be diminished when the sediment remedy is implemented.

The TZW LOE was evaluated by comparing TZW COPC concentrations in individual samples to water effect thresholds. EPA directed the LWG to assume that benthic organisms would be exposed to undiluted shallow (0 to 38 cm) TZW, an assumption that the LWG found to be highly conservative. As discussed in Section 6.6.3.3, actual TZW exposure is probably much lower because of feeding habits, burrowing behavior, avoidance of low oxygen levels at the TZW sample depths, and low food content in sediments at the TZW sample depths.

It is recommended that only those TZW COPCs with HQ ≥ 100 be considered as COCs to develop and evaluate remedial alternatives that are protective of ecological resources.[21] This recommendation is based on two factors. First, by definition any contaminant with HQ ≥ 1 poses potentially unacceptable risk, but the evidence presented in Section 6.6.3.3

[20] The area offshore of the Arkema site was divided into two areas (the acid plant area and the chlorate plant area).

[21] There is uncertainty associated with 4,4′-DDT and total DDx as COCs because HQs based on filtered samples are less than 100. This suggests that the risk from DDx compounds in TZW may be lower than indicated by the maximum concentrations in unfiltered samples due to lower bioavailability of the particulate bound fraction of the contaminant.

strongly supports the position that the potential for unnacceptable risk at HQs < 10 is very small. Therefore, a factor of 10 was applied to account for the evidence that benthic receptors are not directly exposed to undiluted TZW. Second, EPA guidance (EPA 2005a) states that remedies should be evaluated under the assumption that sources of COPCs to the groundwater plume have been controlled. The effect of source control should be to reduce the potential flux of groundwater COPCs into the shallow transition zone prior to sediment remediation. An additional factor of 10 was applied to account for the control of COPC sources.

Almost all metals measured in TZW are common crustal elements. Barium, iron, and manganese are among the most common metals associated with sediments. These same metals are also associated with the highest HQs in the risk characterization, but there is substantial uncertainty that their source is ubiquitously anthropogenic. It is recommended that TZW concentrations of these metals not be used to assess remedy effectiveness.

Given the foregoing, TZW COC recommendations for each site are provided in Table 12-2.

Table 12-2. COC Recommendations for COPCs with HQs ≥ 100 at TZW Sampling Areas

	Maximum HQ ≥ 100									
		Arkema								
COPC	ARCO	Acid Plant	Chlorate Plant	Exxon Mobil	Gasco	Gunderson	Kinder Morgan	Rhône-Poulenc	Siltronic	Willbridge
Contaminants Recommended as TZW COCs										
Benzo(a)anthracene					120				1,200	
Benzo(a)pyrene					210				2,700	
Naphthalene					260				1,100	
4,4′-DDT		160[a]								
Total DDx		280[a]								
Chlorobenzene		190								
cis-1,2-Dichloroethene									110	
Trichloroethene									1,900	
Cyanide					4,400				130	
Carbon disulfide					870					
Contaminants Not Recommended as TZW COCs										
Barium (total)		610	1,100					170		
Iron (total)		110	250	110	130				180	120
Manganese (total)			550	150	130			130		110
Gasoline-range aliphatic hydrocarbons C10-C12[b]					540				150	

[a] Maximum HQs are based on unfiltered samples. Maximum HQs for filtered samples would be 2.8 for 4,4′-DDT (however, this contaminant was never detected) and 14.5 for total DDx.

[b] Petroleum hydrocarbons may contribute to risks to ecological receptors; however, petroleum is not considered a CERCLA contaminant.

CERCLA –Comprehensive Environmental Response, Compensation, and Liability Act
COC – contaminant of concern
COPC – contaminant of potential concern
DDD – dichlorodiphenyldichloroethane
DDE – dichlorodiphenyldichloroethylene
DDT – dichlorodiphenyltrichloroethane
HQ – hazard quotient
total DDx – sum of all six DDT isomers (2,4′-DDD, 4,4′-DDD, 2,4′-DDE, 4,4′-DDE, 2,4′-DDT, and 4,4′-DDT)

Potential remedies should be evaluated in the FS for the degree to which they protect benthic invertebrate communities and individual Pacific lamprey ammocoetes from risk due to contaminated groundwater discharge, assuming that groundwater source control measures have been implemented.

12.3 BENTHIC RISK MANAGEMENT RECOMMENDATIONS

The primary LOE for identifying benthic community risks is based on sediment toxicity (both measured and predicted based on multivariate statistical models [FPM and LRM]); however, the risk assessment methodologies are designed to address chemical mixtures. The results are correlative and do not conclusively identify contaminants causing toxicity.[22] Contaminants whose sediment concentrations, when considered as a group (i.e, in aggregate), appear to help explain the observed toxicity based on the FPM and LRM are presented in Table 12-3.[23]

Table 12-3. Contaminants Potentially Contributing to Benthic Risk Based on Predicted Sediment Toxicity LOE

Contaminant	
Metals	
Cadmium	Lead
Chromium[b]	Mercury[b]
Copper	Silver
PAHs	
2-Methylnaphthalene	Dibenzo(a,h)anthracene
Acenaphthene	Fluoranthene
Acenaphthylene	Fluorene
Anthracene	Indeno(1,2,3-cd)pyrene
Benzo(a)anthracene	Phenanthrene
Benzo(b)fluoranthene	Pyrene
Benzo(b+k)fluoranthene	Total HPAHs
Benzo(g,h,i)perylene	Total LPAHs[b]
Benzo(k)fluoranthene	Total PAHs

[22] Risk conclusions based on the secondary benthic LOEs—tissue residue, surface water, and TZW—can identify COCs and are noted in Sections 12.1 and 12.2, where these LOEs support the identification of COCs.

[23] The contaminant list is a combination of SQVs derived using the FPM and the LRM. Each SQV has a different reporting basis depending on the normalization selected for the model. All FPM SQVs are dry-weight normalized. LRM SQVs used a number of different normalizations including dry-weight, organic carbon, percent fines and combinations of normalizations.

Table 12-3. Contaminants Potentially Contributing to Benthic Risk Based on Predicted Sediment Toxicity LOE

Contaminant	
Chrysene	
Phthalates	
Dibutyl phthalate	
SVOCs	
Benzyl alcohol	Dibenzofuran[b]
1,2-Dichlorobenzene	Carbazole[b]
Phenols	
4-Methylphenol[a]	Phenol
PCBs	
Total PCBs[b]	
Pesticides	
2,4′-DDD	beta-HCH
4,4′-DDD	delta-HCH[b]
4,4′-DDE	Dieldrin
4,4′-DDT	Endrin
Sum DDD[b]	Endrin ketone
Sum DDE	cis-Chlordane
Sum DDT	Total endosulfan[b]
Total DDx	
Petroleum Hydrocarbons	
Diesel-range hydrocarbons	

a All SQVs derived from the FPM are less than the apparent effect threshold and therefore may contribute to false predictions of toxicity.

b FPM SQVs based on one or two endpoints are less than the apparent effect threshold and may contribute to false predictions of toxicity

COPC – contaminant of potential concern
DDD – dichlorodiphenyldichloroethane
DDE – dichlorodiphenyldichloroethylene
DDT – dichlorodiphenyltrichloroethane
FPM – floating percentile model
HCH – hexachlorocyclohexane
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LOE – line of evidence
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
SVOC – semivolatile organic compound
total DDx – sum of all six DDT isomers (2,4′-DDD, 4,4′-DDD, 2,4′-DDE, 4,4′-DDE, 2,4′-DDT, and 4,4′-DDT)

Because the primary benthic LOE (bioassay results) does not identify the cause of the empirical toxicity (i.e., specific COPCs or other factors), the risk management recommendations focus on two other questions:

1. Where were potentially unacceptable benthic community risks occurring in the Study Area at the time of the BERA data collection?

2. What tools from the BERA can be used in the FS analysis of alternatives to assess the effectiveness of potential remedies on protecting the benthic community?

The remainder of this section is arranged around these two questions. Section 12.3.1 outlines the guidelines EPA provided about how to answer them. Section 12.3.2 answers the first question by presenting recommended benthic AOCs. Section 12.3.3 answers the second question by recommending tools by which to assess the effect of potential remedies on the benthic community in the FS analysis of alternatives.

12.3.1 EPA Guidelines for Evaluating Benthic Risk in the Feasibility Study

The LWG and EPA have been working on benthic risk management recommendations since early 2010, following guidelines EPA in an April 21, 2010 letter (EPA 2010a). The guidelines provide direction for evaluating benthic risk in the draft FS. Specifically, EPA described its primary goals for the FS analysis of alternatives for benthic assessment endpoints:

- Define areas that pose unacceptable risk to the benthic community
- Define the areas and volume of contamination that may pose risk to the benthic community
- Evaluate remedial action alternatives and effectiveness (did it meet the RAO)

The letter also provided guidelines for evaluating remedy effectiveness:

- All benthic SQGs in the March 24, 2010 list will be included in the analysis. If specific SQGs are found to be inconsistent with other LOEs listed below, EPA will review the analysis and determine whether these should be included in the draft FS.[24]
- Sediment toxicity bioassays will form the primary LOE for this analysis. The sediment toxicity LOE will include level 2 (moderate) and level 3 (severe) effects for all endpoints (chironomus [sic] biomass and mortality and hyalella [sic] biomass and mortality).

[24] The SQVs have subsequently been revised based on additional modeling and negotiations between the LWG and EPA, as documented in item 11 of Attachment B to a January 12, 2011, LWG letter to EPA (LWG 2011a), the attachment to a February 25, 2011, RI/FS schedule letter from EPA to the LWG (Humphrey 2011), and the LWG's March 9, 2011, draft response (LWG 2011b) to EPA's February 25, 2011, letter.

- The analysis will consider the number and degree of exceedance of SQGs.
- The analysis will consider other LOEs such as TZW compared to ambient water quality criteria for the protection of aquatic life and benthic tissue TRVs.
- The analysis will consider the presence/absence of nearby sources and examine benthic community structure (e.g., via sediment profile imaging and related information).
- The analysis will consider data quality and data density issues for the SQGs.

The LWG's implementation of these guidelines is known by EPA and the LWG as the "comprehensive benthic approach." Developed by the LWG after receiving the EPA's April 21, 2010, directives and guidelines (EPA 2010a), the comprehensive benthic approach was first presented informally to EPA (Eric Blischke and Burt Shephard) by the LWG (John Toll and Jim McKenna) on July 20, 2010, to elicit early feedback. It was formally presented to EPA during the September 29, 2010, LWG Small Technical Group Benthic Toxicity AOPCs Meeting with EPA. Item 11 in Attachment B to the LWG's January 12, 2011, letter to EPA (LWG 2011a), and the attachment to EPA's February 25, 2011, response letter to the LWG (Humphrey 2011) document the decision to proceed with an updated version of the comprehensive benthic approach.

12.3.2 Recommended Benthic Areas of Concern for FS Evaluation

Recommended benthic AOCs, based on the LWG's application of the comprehensive benthic approach upon completion of the draft final BERA, are shown on Maps 12-1a and 12-1b. Sediment toxicity bioassays form the primary LOE for the comprehensive benthic approach used to delineate the recommended benthic AOCs, as per the EPA April 21, 2010, guidelines (EPA 2010a). Predicted toxicity (based on multiple sets of SQVs) and tissue residues (both empirical and predicted) provide secondary LOEs to identify benthic risk areas. TZW and surface water were used as supporting LOEs.

SPI data were not used in the development of AOCs because the sampling program was not designed to link SPI image locations with toxicity sampling locations and in turn allow an assessment of the relationship between benthic community successional stage and contaminant effects. Details of the approach used to identify recommended benthic AOCs are as follows:

- Locations with empirical bioassay results indicating significant toxicity were identified.
  - One toxicity endpoint (*Chironomus* biomass or growth, *Hyalella* biomass or growth) exceeding an L3 threshold or two endpoints exceeding an L2 endpoint were considered significant toxicity.

- Locations where significant sediment toxicity is predicted based on sediment chemistry exceeding an MQ of 0.7 or a pMax of 0.59 were identified.
  - Sampling locations where both the MQ and the pMax thresholds were exceeded were considered toxic.
  - Sampling locations where neither the MQ or pMax threshold was exceeded were considered non-toxic.
  - Sampling locations where the models disagreed (i.e., either the MQ or the pMax threshold was exceeded, but not both) were considered uncertain.
- Locations where empirical tissue residues or, in the absence of empirical tissue residue data, predicted tissue residues exceeded their TRVs were identified.
  - The evidence of risk provided by measured or predicted exceedance of metals TRVs was considered weak because of species-specific differences in metals sequestration or other bioregulation.
  - The evidence of risk provided by predicted exceedance of the TBT TRV was considered weak because of high uncertainty in the TBT bioaccumulation model.
- TZW exceedance areas with HQs > 100 were delineated.
- All LOEs were overlaid on a map.
  - Areas where two or more adjacent empirical bioassay sampling locations indicate significant toxicity were identified as benthic AOCs.
  - Areas where risks were identified at two or more adjacent sampling locations based on chemistry LOEs (predicted toxicity, empirical or predicted bioaccumulation) or a combination of bioassay and chemistry LOEs were identified as benthic AOCs.
  - TZW exceedance areas were identified as benthic AOCs.
- Boundaries of the benthic AOCs split the distance between sampling locations exceeding criteria and surrounding clean sampling locations except where:
  - Other physical features were present (e.g., pier, channel edge, property boundary), in which case the boundary was drawn at the physical features.
  - The nearest sampling sampling location was at a distance greater than 200 ft, in which case the boundary was drawn at a subjective distance less than halfway to nearest sampling location.

12.3.3 Benthic Assessment Tools for the FS Analysis of Alternatives

Bioassays cannot form the primary LOE for the FS analysis of alternatives, because the analysis is of potential future conditions. Therefore, the sediment chemistry LOE, as applied in the comprehensive benthic approach, will have to be used to judge protectiveness of potential remedies. The comprehensive benthic approach uses concordance between an MQ based on the site-specific SQVs and the predicted pMax to identify benthic risk areas. EPA selected the MQ threshold of 0.7 and the pMax threshold of 0.59 that the LWG used in defining benthic AOCs. These same thresholds should be used to evaluate the protectiveness of potential remedies. The analysis of alternatives should also consider whether and how much natural recovery would occur prior to implementing active remedies. Per EPA guidance (EPA 2002b, 2005a), the analysis should presume that source control measures will be in place.

12.4 SUMMARY OF RISK MANAGEMENT RECOMMENDATIONS

The purpose of the risk management recommendations provided in Section 12 is to identify COCs, receptors, and AOCs that the LWG considers necessary and sufficient to develop and evaluate remedial alternatives that are protective of ecological resources. The FS will also evaluate whether remedial alternatives for these COCs, receptor and AOCs address the full list of contaminants potentially posing unacceptable risk.

In summary, the following are recommended as receptor-COC pairs of concern for futher consideration in the FS:

- For non-benthic invertebrate receptors, total PCBs and total TEQ are the recommended COCs. Mink is the recommended receptor of concern. Most of the contaminants posing potentially unacceptable risk were not recommended as COCs for the non-benthic receptors based on risk characterization considerations (magnitude, spatial extent, and ecological significance of HQs ≥ 1). This list includes all the metals, butyltin, phthalate, pesticide, and VOC COPCs.
- For aquatic receptors exposed via TZW, 4,4′-DDT, total DDx,[25] chlorobenzene, benzo(a)anthracene, benzo(a)pyrene, naphthalene, carbon disulfide, cyanide, cis-1,2-dichloroethene, and trichloroethene are the recommended COCs. These recommendations presume that contaminated groundwater source control measures will be implemented prior to sediment remedies. ODEQ is working with upland property owners to implement contaminated groundwater source control measures prior to sediment remedies.
- For benthic organisms, recommended benthic AOCs were mapped by applying the comprehensive benthic approach based on EPA’s April 21, 2010, guidelines for assessing benthic risk in the FS (EPA 2010a). The FS analysis of alternatives will have to rely on the predicted toxicity metrics to evaluate potential remedies and should take into account sediment quality changes that will take place before active implementation of remedies.

[25] There is uncertainty associated with 4,4′-DDT and total DDx as COCs because HQs based on filtered samples are less than 100. This suggests that the risk from DDx compounds in TZW may be lower than indicated by the maximum concentrations in unfiltered samples because of the lower bioavailability of the particulate-bound fraction of the contaminant.

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